1977

WORKING PLAN

Pilot Surveys To Measure Annual Mortality Caused By The Mountain Pine Beetle In Lodgepole And Ponderosa Pine

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Figure 1. Generalized Distribution of a Mountain Pine Beetle Outbreak in Lodgepole Pine on the Targhee National Forest in 1976.

Figure 2. Generalized Distribution of a Mountain Pine Beetle Outbreak in Ponderosa Pine on the Black Hills National Forest in 1976.

WORK PLAN

PILOT PROJECT TO MEASURE ANNUAL MORTALITY CAUSED BY THE MOUNTAIN PINE BEETLE IN LODGEPOLE AND PONDEROSA PINE

INTRODUCTION

This is the first in a series of pilot surveys leading to the measurement of damage caused by forest insects and disease on a State-wide basis using aerial photography. This initial survey will attempt to measure annual mortality of lodgepole and ponderosa pine caused by the mountain pine beetle, Dendroctonus ponderosae Hopkins, in epidemic areas on two National Forests; the Targhee National Forest, Idaho, and the Black Hills National Forest, South Dakota and Wyoming. If this and subsequent pilot surveys prove to be practical and cost effective, they will subsequently be modified and expanded to cover much larger areas, such as a State, a Region, and eventually all States.

These and other damage surveys stem from the need to know both the intensity and extent of forest pest related damage to the forest resource. Recent efforts to accumulate meaningful forest insect caused loss information by the Western Forest Insect Issues Study has shown the need for this important data, and it has also shown that the data base from which this information was drawn was uncertain, and in specific cases, totally lacking.

On-going resource inventory systems such as the National Forest Inventory and Forest Survey, provide a periodic inventory of the timber resources, but the methodology, frequency, and the intensity of these

systems do not provide for measurement and identification of annual tree losses caused by specific forest pests. Since the combined effects of forest insects and diseases cause more tree mortality than from all other causes combined, and their consequences directly impact program management at all administrative levels, it is imperative that these losses be monitored and quantified. At this time, there are no operational methods for measuring these losses with a satisfactory level of confidence; consequently, the reason for this pilot survey.

A Working Group comprised of individuals from all of the western Regions (except 10), and the Pacific Southwest and Rocky Mountain Forest and Range Experiment Stations was formed to achieve west-wide participation in the planning and conduct of these and other damage surveys. The Working Group met at MAG, Davis, California, on December 14-15, 1976, to identify fundamentals for designing and implementing these two surveys. The design and methods outlined in this plan, therefore, are, for the most part, a concensus of the Working Group.

OBJECTIVE

The objective of this pilot survey is to design and implement a multistage sampling system, utilizing existing technology, for measuring (1) annual and (2) cumulative tree mortality of lodgepole and ponderosa pine caused by the mountain pine beetle. Although the initial phase will be limited in scope - a National Forest - it will be flexible in design for subsequent modification and expansion to a much larger area.

This survey will provide the following information:

1. The number, diameter distribution, and cubic foot volume of lodgepole and ponderosa pine killed in 1976 (1977 faders) (Tables 3 & 4).
2. The number, diameter distribution, and cubic foot volume of merchantable standing lodgepole and ponderosa pine killed during 1975 and before (snags) (Tables 3 & 4).
3. Basal area ratio of residual green stand (all species) to standing dead.
4. The ratio of new attacks (1977) to old (1976). (Although these measurements are not in accord with survey objectives, they are easily procured, and desired by R-2 Entomologists for evaluation purposes).

AREAS

This pilot project will involve two separate and distinct pilot surveys, one to measure annual mortality of lodgepole pine on the Targhee National Forest, and the other for annual mortality of ponderosa pine on the Black Hills National Forest.

BACKGROUND

The mountain pine beetle is easily the single most damaging forest insect in the western United States and Canada. It attacks and kills practically all western pines and is currently epidemic in portions of Colorado, Idaho, Montana, Oregon, South Dakota, Utah, and Wyoming. Particularly, serious outbreaks are now in progress in portions of the Targhee and Black Hills National Forests.

TARGHEE NATIONAL FOREST - The Targhee National Forest in southeast Idaho and western Wyoming contains vast, unbroken areas of lodgepole pine. Most of these pure stands (> 4-inches dbh) range in age from 50-200 years, are infested with dwarf mistletoe, and are slow growing. Man has intensfied this condition in two ways: first, fire has been successfully excluded; secondly, there has been little opportunity to harvest the stands and convert them to a less vulnerable state, due to low demand for lodgepole pine.

Reports of mountain pine beetle outbreaks on the Targhee are sketchy, but records show that significant outbreaks occurred during the late twenties and again during the forties. The current infestation was detected in the southern part of the forest in 1958, reached spectacular and damaging proportions, and continues to this day.

Chemical control projects, costing upwards of 8 million dollars were started in 1959 but stopped in 1970 due to their ineffectiveness. In the southern half of the Forest, the outbreak has subsided, but in the northern half, in most of the Island Park District and in the east end of the Dubois District, heavy tree killing continues. In an area near the base of Sawtell Peak, the 1976 infestation reached a level of 25 trees per acre (Gibson 1977). During the course of the outbreak, upwards of 100 trees (> 5-inches dbh) per acre have been killed over an eight year period on the Ashton Ranger District (Klein 1976).

Approximately 275,000 acres will be surveyed.

BLACK HILLS NATIONAL FOREST - Records of mountain pine beetle activity in ponderosa pine in the Black Hills reach back as far as the late 1800's. Although no data was available on losses, it was thought to be considerable. The towns of Deadwood and Whitewood were supposed to have derived their names from the expanse of dead ponderosa pine left in the aftermath of these early outbreaks. Since then, outbreaks have developed and waned in various areas, with the present epidemic beginning in the mid 1960's.

From 1964 to 1970, more than 3 million dollars was spent on chemical control, but like the Targhee project, it too was ineffective in stemming the tide. In 1971, chemical suppression was terminated, and efforts were redirected toward salvage of beetle infested and killed trees and an accelerated timber harvest program, which is still in progress. The current outbreak covers more than one million acres with the heaviest concentration of beetle activity in the north in portions of the Spearfish Ranger District. Significant, but less damage also occurs in parts of the Nemo, Elk Mountain, Harney, and Bear Lodge Ranger Districts.

METHODS

Color and color infrared aerial photography combined with ground surveys has proved to be an effective and economical method for measuring damage caused by forest insects (Wear et al., 1966; Aldrich and Drooz, 1967; Ciesla et al., 1967; Wert and Roettgering, 1968; Heller 1974). Heller et al., (1968), for example, found that color

and color infrared photography at scales of 1:8000 and smaller were effective in detecting faded ponderosa pine killed by the mountain pine beetle in the Black Hills, and that at the larger scales, color was as effective as color infrared. Using a standard 35 mm camera and color film taken at a scale of 1:5000, Klein (1973) was successful in detecting and separating attacked (faders) and standing dead lodgepole pine also killed by the mountain pine beetle. In these pilot surveys, color aerial film (SO 397) will be used at a mean scale of 1:6000.

SURVEY TIMING - The sequence of events and timing of these major survey phases will depend on the incidence of crown discoloration (fading), and since this phenomena is not simultaneous between area, the sequence of these primary activities will vary accordingly, (Table 1).

Table 1. Sequence of Major Survey Activities.

Forest	Tree Species	Earliest Dates For		
		Sketchmapping	Aerial Photography	Ground Truth
TARGHEE	Lodgepole	7/5	8/1	8/15
BLACK HILLS	Ponderosa	8/1	8/22	9/12

The Targhee and Black Hills are both experiencing unprecedented droughts and if this trend continues, tree fading may occur earlier than shown in Table 1.

SURVEY DESIGN - The survey design for both outbreaks in the Targhee and Black Hills will be essentially similiar with some individual modifications. Basically, the design will entail a randomized multistage sampling system initially stratified into three intensity classes or strata. Stratification will be from current aerial sketchmap surveys. Wert and Roettgering, (1968) effectively used sketchmapping to stratify various intensities of Douglas-fir beetle damage as a basis for photographic sampling. In the Black Hills, Heller and Wear (1969) utilized aerial sketchmap data as a base for a multistage probability sampling system to provide loss estimates of ponderosa pine by the mountain pine beetle. The sketchmapping and stratification will be followed by large scale aerial photography and on-the-ground measurements. The ground sample will provide a check on the consistency of the larger photo sample, and permit adjustment of the photo sample by linear regression or a ratio estimator for number of trees and volume killed. Additional ground measurements will be made to determine the basal area ratio of the residual live stand to dead, and in the Black Hills, the ratio of new attacks (1977) to old (1976).

Stratification. Stratification will be done to minimize the variance of estimates of totals. The three strata will be delineated on a map and sampled separately. Strata selection will be by one of two methods: the first by assignment of equally spaced class intervals and the second, by selecting approximately an equal number of trees in each class. Examples of these alternative methods as derived from 1976 Targhee sketchmap data follow:

1. CLASS INTERVALS

Strata	Class Int. (Trees/ Acre)	1976 Faders	Area (Acres)	$\bar{x}$ No. Faders Per Acre	No. n	PHOTO PLOTS Possible Size (Acre)	No. M 1/	Percent Sample
I	< 1.0	57,500	134,900	0.4	60	40	3373	0.02
II	1.0 - 2.0	67,800	50,500	1.3	60	22.5	2244	0.03
III	> 2.0	158,500	48,400	3.3	60	10	4840	0.01
TOTAL		283,800	233,800	- -	180			

1/ Maximum number of plots within stratum.

2. EQUAL NUMBER OF TREES

Strata	Class Int. (Trees/ Acre)	1976 Faders	Area (Acres)	$\bar{x}$ No. Faders Per Acre	No. n	PHOTO PLOTS Possible Size (Acre)	No. M	Percent Sample
I	< 1.5	92,400	165,300	0.6	60	40	4132	0.01
II	1.5 - 3.2	92,500	44,400	2.1	60	22.5	1973	0.03
III	> 3.2	98,900	24,300	4.1	60	10	2430	0.02
TOTAL		283,800	233,800	- -	180			

The heavier strata will be sampled more intensely than the lighter strata. In these examples, however, the most intense stratum (III) is undersampled, compared to the two light strata. If the 1977 sketchmap data shows essentially the same distribution and intensity, it may be necessary to vary the number and size of photo plots within strata, realizing that any overall increase may also increase the photo interpretation phase.

Stratification into the three intensity classes will follow the completion of the aerial sketchmap survey. After each days' flying, map areas (Polygons) will be digitized using an electronic planemeter and converted to density (trees per acre). Once the survey is complete and all of the survey area digitized and converted, the individual polygons will be listed in ascending order by computer (via telephone link) and subdivided into their respective intensity classes or strata.

Photo Plots - The primary sampling unit will be the photo plot. There will be approximately 180 photo plots on the Targhee and 300 on the Black Hills. Since there are considerable differences in both the distribution and intensity of mountain pine beetle killed trees between the Targhee and Black Hills outbreaks, the size of the photo plots will also vary between infestation and strata (Table 2). An analysis of 1976 aerial sketchmap data, for example, shows the Targhee outbreak to be more uniform and intense than the Black Hills outbreak, thereby, requiring different size plots:

Table 2. Number and Size of Aerial Photo Plots

	TARGHEE			BLACK HILLS	
Strata	No.	Size (acres)	Dimension (chains)	No.	Size (acres)	Dimension (chains)
I	60	40	20 x 20	100	90	30 x 30
II	60	22.5	15 x 15	100	62.5	25 x 25
III	60	10	10 x 10	100	40	20 x 20
TOTAL	180	- -	- -	300	- -	- -

So as to maintain a systematic distribution of photo points over the entire area and within stratum, and to facilitate ease of flying to the extent possible, flight line width and photo point interval will also vary between stratum.

Once the photography is obtained, and time permitting, there may be other combinations of varying photo plot size within each stratum used to achieve more efficient estimates. An alternative method would be multistage sampling in the second stage (photo plots) using equal size plots (say 40 acres) and partitioning the plots into equal 10 acre subplots. Tree count estimates would be made for the entire 40 acre plot with the selection of the photo interpretation subplot based on probability proportional to the estimates of the numbers of faders.

The procedure used to select the photo plot for ground truth will be such that every tree counted on the photo has a known chance of selection. The method will entail a systematic selection based on the total trees counted in each stratum. The resulting subsample will be a self-weighting, independent sample. More than one subsample could fall into a photo plot. The tree then becomes the sampling unit for subsampling.

Ground Plots - Photo subplots or ground check plots will be 2.5 acres (5 x 5 chains) in size. There will be approximately 20 ground plots per stratum or 60 ground plots in all. Ground plot selection within selected photo plots will be determined by an accumulation of the 2.5 acre ground plots. The subunit containing the i^{th} selected tree (determined from the original selected photo plot) will be the subunit selected for ground work.

AERIAL SKETCHMAPPING - Aerial sketchmapping for various kinds of forest pest problems is routine FI&DM procedure. Both Forests will be flown and mapped by experienced aerial surveyors as soon as 95 percent of the 1976 attacked trees show obvious discoloration. The infestations will be flown to the same standards using standard forest maps (1/2-inch equals one mile or 1:126,720) at a maximum flying height of 1500 feet above terrain and not in excess of 120 miles per hour. Assuming favorable weather conditions, approximately 12 and 30 hours will be required to fly and map the Targhee and Black Hills outbreaks respectively.

Although the photographic missions will be based on the 1977 aerial sketchmap surveys, they will be compared with the 1976 sketchmaps to test them, as an alternate basis for the initial stratification. If the infestation intensity and distribution does not change materially, a year's lead time would facilitate planning and eliminate the critical period between mapping and photography. It would also permit the sketchmapping to be done much later in the summer or fall.

AERIAL PHOTOGRAPHY

Once the sketchmap survey is completed, the boundaries of the infestation delineated, and the three strata defined; a series of photo points will be established within each stratum of the outbreak area using a one-mile square grid overlay. Flight lines will be north-south with the east-west intercepts being potential photo points. Photo plot intervals and the location of the first plot along each flight line will be randomly selected.

Forest Service personnel and aircraft will take the aerial photography. Plans at this time, are for the Remote Sensing Team from Region 6 (Portland) to photograph the Black Hills and the Photogrammetry Unit from Region 4 (Ogden) to photograph the Targhee.

Within each infestation, an equal number (or nearly so) of photo points will be assigned to each strata. The heavier stratum (III) will be sampled more intensely than the lighter strata (I and II), since stratum III will probably be the smallest in area, stratum II, the next

smaller area, and stratum I, the largest. However, these numbers will be adjusted somewhat if one or more strata is unduly large - or small. A few additional photo points will be randomly established outside the outbreak boundaries (zero stratum) as a check on the accuracy of boundary delineation and strata assignment.

PHOTO PROCESSING AND PREPARATION - Once 2 to 3 rolls of film are completed, they will be shipped air express to a commercial processor in Eugene, Oregon. Processing and return should not exceed 5-7 days. Once the processed transparencies are received, each photo will be assigned strip and photo numbers, and located on U.S.G.S. topographic maps and/or resource photography.

Photo scale will be determined by computing the difference between the elevation of the center of the plot on the topographic map and the altitude of the aircraft at the time the photo was taken. A series of transparent overlays (see Appendix) inscribed with plot boundaries and representing a range of scales (1:5400-6600) will be prepared, and the appropriate transparency overlain on the photo. Each photo plot will be further subdivided into 2.5 acre (5 x 5 chains) subplots for ease of interpretation and for ground checking.

PHOTO INTERPRETATION - Photo interpretation will be done by two or three experienced photo interpreters using conventional sterescopic technique and equipment. Prior to the interpretation phase, the interpreters will receive on-the-ground training for first hand comparisons of fading trees and snags as they appear on the photos and on the ground. Procedures used for this phase follow:

1. Separate the photos by their appropriate stratum.
2. Providing the stereo triplet is of acceptable quality, select the first two transparencies (stereo pair) and delimit the effective area with opaque ink. Locate the center of the effective area by the intersection of two diagonal lines.
3. Considering stratum and scale, select the appropriate template and position it so that its center coincides with that of the effective stereo area.
4. Count all 1977 faders within plot boundaries, keeping counts separate by 2-1/2 acre subplot.
5. Count all snags within photo plot, keeping counts separate by 2-1/2 acre subplot.
6. Ground check plots will be randomly selected within stratum. Once plot is located, inscribe its borders by scratching with a pointed instrument or with opaque ink on the reverse (emulsion) side of the transparency.

GROUND TRUTH - Once photo counts are complete in a stratum, ground check surveys of that stratum will begin. There will be 20 ground truth plots in each stratum, or a total of 60 plots per infestation. No ground truth plots will be placed in the zero stratum. Since mortality intensity in each stratum is inversely related to its area, this means that the heavier strata will be sampled more intensely than the lighter strata, as it should be, for this concentrates sampling in the areas of heaviest activity and larger volumes.

Photo plots will be located using forest maps and resource photography. Once the photo plot is located on the ground, the 2-1/2 acre ground truth plots will be located and examined using the color transparencies. Transparencies will be placed in a light weight plastic film holder and examined steroscopically by a pocket stereoscope and transmitted sunlight. Procedures for taking ground plot data follow:

1. Locate plot center and corners. To facilitate ease of examination and orientation, mark boundaries and one-chain wide lanes with string in each plot.
2. Locate and record dbh by 1-inch class [1/] all (1) 1977 faders, (2) snags [2/] and (3) 1977 attacks (Black Hills only) 5-inches dbh and greater. Measure total height of at least two trees in each diameter class in categories 1 and 2 combined.
3. Establish a cluster of 5-variable plots with the central variable plot located at plot center and four remaining plots in each of 4 cardinal directions at 2 chain intervals from center.
4. In each variable plot, using a Spiegal-Relascop (BAF10) on a jake staff, record all live trees by species and all dead pine 5-inches dbh and greater. Measure borderline trees (inside face) using limiting distance table.
5. Record elevation at plot center with altimeter.

1/ Targhee: Dbh class midpoint at full inch mark, i.e., 9-inch class includes 8.6 - 9.5.

Black Hills: Dbh class midpoints at half-inch mark, i.e., 9-inch class includes 9.0 - 9.9.

2/ It is assumed that nearly all of the standing snags were killed during the current outbreak.

DATA ANALYSIS - Rather detailed statistical specifications have been prepared describing the formulae used to generate the output tables. These specifications are rather lengthy and were developed for use by systems analysts/programmers for development of a data processing system. These specifications are available upon request.

The sample design is planned to provide estimates of the number of trees killed and volume loss at the 5 percent level for each survey area.

Ratio and regression estimators will be used to estimate for the number of faders, ratio and regression estimation:

1. Ratio estimator for $\hat{X}$, total number of faders in a stratum

$$\hat{X}_\ell = \left[\frac{M_\ell}{m_\ell} \sum_{i=1}^{m_\ell} \sum_{j=2}^{N_i} X_{\ell_{ij}} \right] .R_\ell$$

where R_ℓ is the mean of the ratios of the ground count in photo count for each of the selected ground plots, $X_{\ell_{ij}}$ is the number of faders counted on the photo in the j^{th} subunit from the i^{th} photo in the ℓ^{th} stratum. M_ℓ is the number of possible photo plots in the ℓ^{th} stratum and m_ℓ is the number of photo plots selected in the sample.

2. Regression estimators for $\hat{X}_\ell$, total number of faders in

$$\hat{X}_\ell = A_\ell \left[\overline{Y}_{2_\ell} + b_\ell \left(\overline{X}_{1_\ell} - \overline{X}_{2_\ell} \right) \right] \overline{X}_{2_\ell}$$

a stratum where $\overline{X}_{2_\ell}$ is the mean per acre determined from the small photo subsample, $\overline{X}_{1_\ell}$, is the mean per acre determined from the large aerial photo sample, $\overline{Y}_\ell$, is the number of faders per acre determined

from the ground samples, and b_ℓ is the regression coefficient from the regression of photo counts (X_2 independent variable) to the ground counts (Y_2 dependent variable), and A_ℓ is the number of acres in the populations in the ℓ^{th} stratum.

3. Volume estimates per tree will be determined for each subunit based on an overall dbh and height distributions from volume equations (Targhee) and local volume tables (Black Hills).

TIME TABLE OF ACTIVITIES

Listed below is a step-by-step sequence of survey activities and proposed dates for the initiation and completion of these activities and their accomplishments. Due to the critical nature of the survey time frames and the unpredictable events that may occur, specifically inclement weather, the proposed dates may vary somewhat, but the overall sequence of activities should remain unchanged.

ACTIVITY	DATES	
	TARGHEE	BLACK HILLS
1. Draft Work Plan	March 1	March 1
2. Final Work Plan	April 15	April 15
3. Purchase Film & Equipment	March 1 - 15	March 1 - 15
4. MAG-Region Coord. Meeting	March 21 - 22	March 14 - 15
5. Aerial Sketchmapping		
a. Training	July 5 - 6	August 1 - 2
b. Sketchmapping	July 7 - 12	August 3 - 11

c. Digitizing	July 8 - 13	August 4 - 12
d. Strata Determination	July 14	August 15
6. Aerial Photography		
a. Planning, Plot & Flight Line Determination	July 14 - 15	August 15 - 16
b. Photo Crew Orientation	August 1	August 22
c. Aerial Photography	August 1 - 10	August 22 - 31
d. Film Shipment & Process	August 2 - 15	August 23 - September 19
e. Annotation & Organization	August 8 - 22	August 29 - September 19
7. Photo Interpretation		
a. Interpreters on Board	August 8	August 29
b. Training	August 8 - 9	August 29 - 30
c. Photo Interpretation	August 10 - September 2	August 31 - September 23
8. Ground Suveys		
a. Field Crews on Board	August 15	September 12
b. Training	August 15 - 17	September 12 - 14
c. Ground Truth	August 18 - September 9	September 15 - October 7
9. Data Compulation	August 19 - September 16	September 13 - October 14
10. Data Analysis	September 19 - October 28	October 17 - December 2
11. Final Report		
Preliminary Statistics	December 31	December 31
Draft Report	January 27	January 27
Final Report	February 28	February 28

Responsibilities And Duties

Region 2 and 4's primary function is to organize and conduct the pilot surveys while MAG's principal roles are planning, coordinating, and reporting. A more detailed breakdown of these responsibilities follows:

REGIONS 2 and 4

1. Select survey areas.
2. Contact and maintain liaison with affected forests.
3. Assist in planning.
4. Conduct surveys.
    a. Hire field personnel
    b. Provide transportation
    c. Supply or purchase required equipment and materials (except film)
    d. Through transfer of funds, pay for aerial photography and required travel and per diem of photo interpreters and MAG advisor
5. Assist in data compilation.
6. Assist in final report.

METHODS APPLICATION GROUP

1. Assist in selection of survey areas.
2. Prepare working plan.
3. Coordinate inter-regional activities.
4. Purchase film and pay for telephone linkup and computer time.
5. Modify existing pertinent data programs or write new one.
6. Arrange for aerial photography.
7. Arrange for photo interpreters.
8. Process and analyze data.
9. Prepare final report.

PILOT SURVEY ORGANIZATION

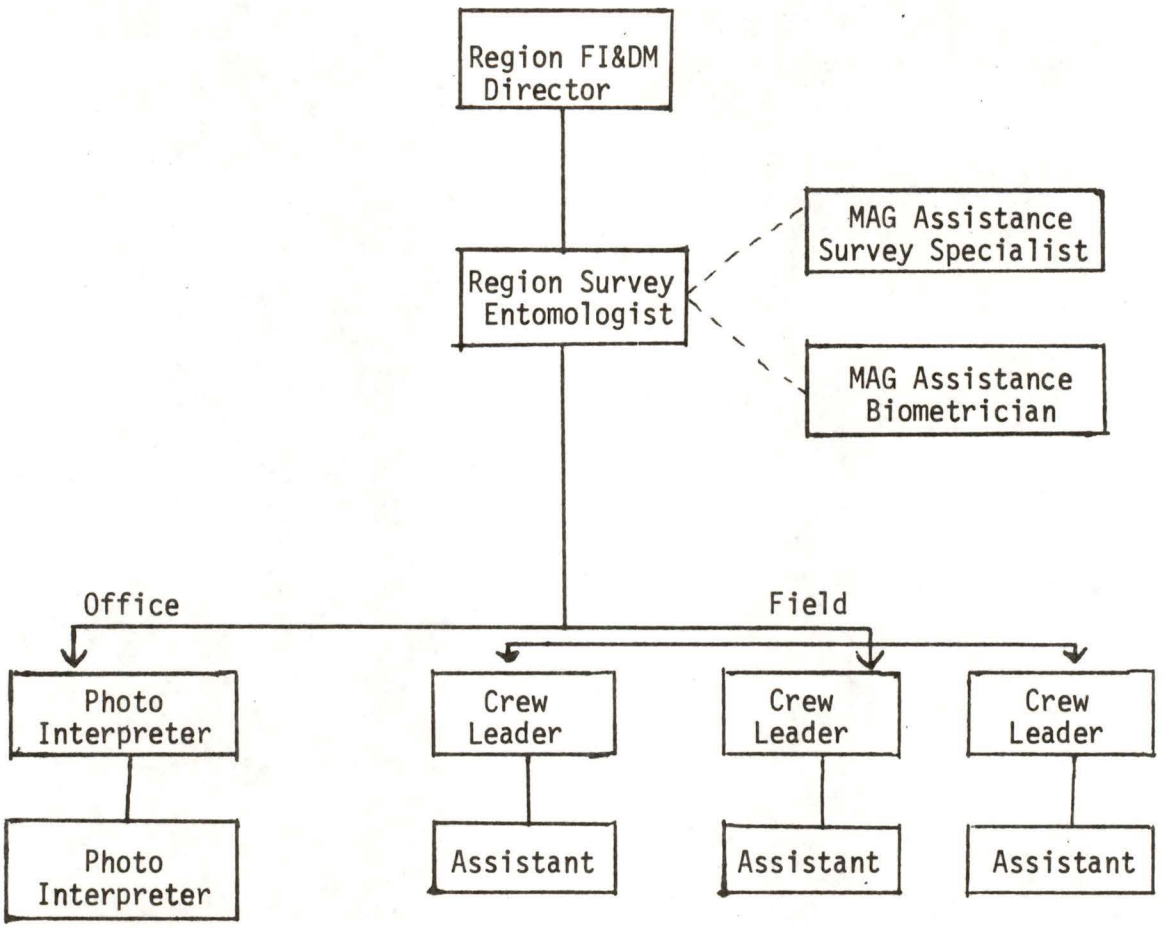

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TABLE 3. DIAMETER DISTRIBUTION OF _____ PINE KILLED

BY THE MOUNTAIN PINE BEETLE, _____ NATIONAL FOREST, 1977

STRATA	NO. TREES PER ACRE	DIAMETER										TOTAL		SE%
		5	6	7	8	9	10	11	12	Z	20	PER ACRE	STRATA	
1	FADERS													
	SNAGS													
	TOTAL													
2	FADERS													
	SNAGS													
	TOTAL													
3	FADERS													
	SNAGS													
	TOTAL													
											INFESTATION TOTAL			

TABLE 4. CUBIC FOOT VOLUME OF _____ PINE KILLED BY

THE MOUNTAIN PINE BEETLE, _____ NATIONAL FOREST, 1977

STRATA	NO. TREES PER ACRE	DIAMETER										TOTAL		SE%
		5	6	7	8	9	10	11	12	Z	20	PER ACRE	STRATA	
1	FADERS													
	SNAGS													
	TOTAL													
2	FADERS													
	SNAGS													
	TOTAL													
3	FADERS													
	SNAGS													
	TOTAL													
												INFESTATION TOTAL		

EQUIPMENT AND MATERIALS

ITEM	NUMBER REQUIRED	ON HAND REGION	ON HAND MAG	NEED TO PURCHASE
OFFICE				
Film (SO 397)				
TARGHEE (Rolls)	4	(MAG will purchase)		
BLACK HILLS (Rolls)	6	(MAG will purchase)		
Old Delph Stereoscopes	2		1	
Light Tables, Portable	4		2	
Pocket Calculators	2		1	
Rapidograph Pens	4			
Felt Tip Pens (Sharpie)	12			
Lamps, Desk	4			
Pencil Sharpener	1			
Scissors	2			
Straight Edge, Metal	1			
Mylar, Plastic 3' x 25'	1			
Pencils, Mars-Omnichrom	12			
Ink, Opaque, vary colors	6			
Film Boxes	4			
Topo Maps (complete sets)	3			
Forest Maps (1/2" = Mile)	6			
Electronic Digitizer	1	(Possible Sources: PSW, R-1, R-4)		
Resource Photography (set)	1			
Triangles, Drafting	2			
Tape, Masking (Rolls)	2			

ITEM	NUMBER REQUIRED	ON HAND REGION	MAG	NEED TO PURCHASE
FIELD				
Spiegel-Relascops	3			
Jake Staffs	3			
50-Ft. Loggers Tape	3			
2-Chain Tape with Trailers	3			
Clinometers	3			
Tatums	3			
Lumber Crayons, Red	12			
Pocket Stereoscopes	4			
Knapsacks	3			
Wood Stakes	500			
Hatchets	6			
Transparent Film Holders	3			
Twine, Rolls (2-1/8 Mile)	25			
Altmeters, Pocket	3			
Cruiser Vests	3			
Hard Hats	6			
Diameter Tapes	6			
Refills	3			
Tables, Limiting Distance	6			
Compasses, Silva Ranger	3			
Flagging, Plastic, Red (Rolls)	48			
Film Holders, Soft Plastic	150			
Tape, Plastic (Rolls)	6			

PHOTO INTERPRETATION WORKSHEET

FOREST _____ INTERPRETER _____ DATA _____ PLOT SIZE _____

FLIGHT LINE _____ STRATA _____ PHOTO NOs. _____

SUBPLOT NO.	NUMBER OF FADERS	NUMBER OF SNAGS	REMARKS	SUBPLOT NO.	NUMBER OF FADERS	NUMBER OF SNAGS	REMARKS
SUBTOTAL							
				TOTAL			

COMMENTS:

GROUND PLOT WORKSHEET

- MOUNTAIN PINE BEETLE MORTALITY -

FOREST _____ OBSERVERS _____ DATE _____ STRATA _____

PLOT SIZE (AERIAL) _____ (GROUND) _____ PHOTO NOS. _____

MAKE ENTRIES THUS: ::, 4; ⊐, 7; ⊠, 10. ELEVATION _____

	TREE COUNT						TREE HEIGHT					REMARKS
DBH	1976	T	1977	T	SNAGS	T	1	2	3	T	$\bar{x}$	
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
TAL												

COMMENTS:

VARIABLE PLOT CLUSTER TALLY

MOUNTAIN PINE BEETLE DAMAGE SURVEY

FOREST _____ OBSERVERS _____ DATE _____ PHOTO NO. _____

MAKE ENTRIES THUS: ::, 4; ⊠, 6; ⊠1, 10.

SPECIES	CONDITION	VARIABLE PLOT 1		2		3		4		5		REMARKS
		No.	T	No.	T	No.	T	No.	T	No.	T	
PINE	LIVE											
	DEAD											
WBL	LIVE											
	DEAD											
SPRUCE	LIVE											
FIR	LIVE											
FIR	LIVE											
TOTAL												

COMMENTS:

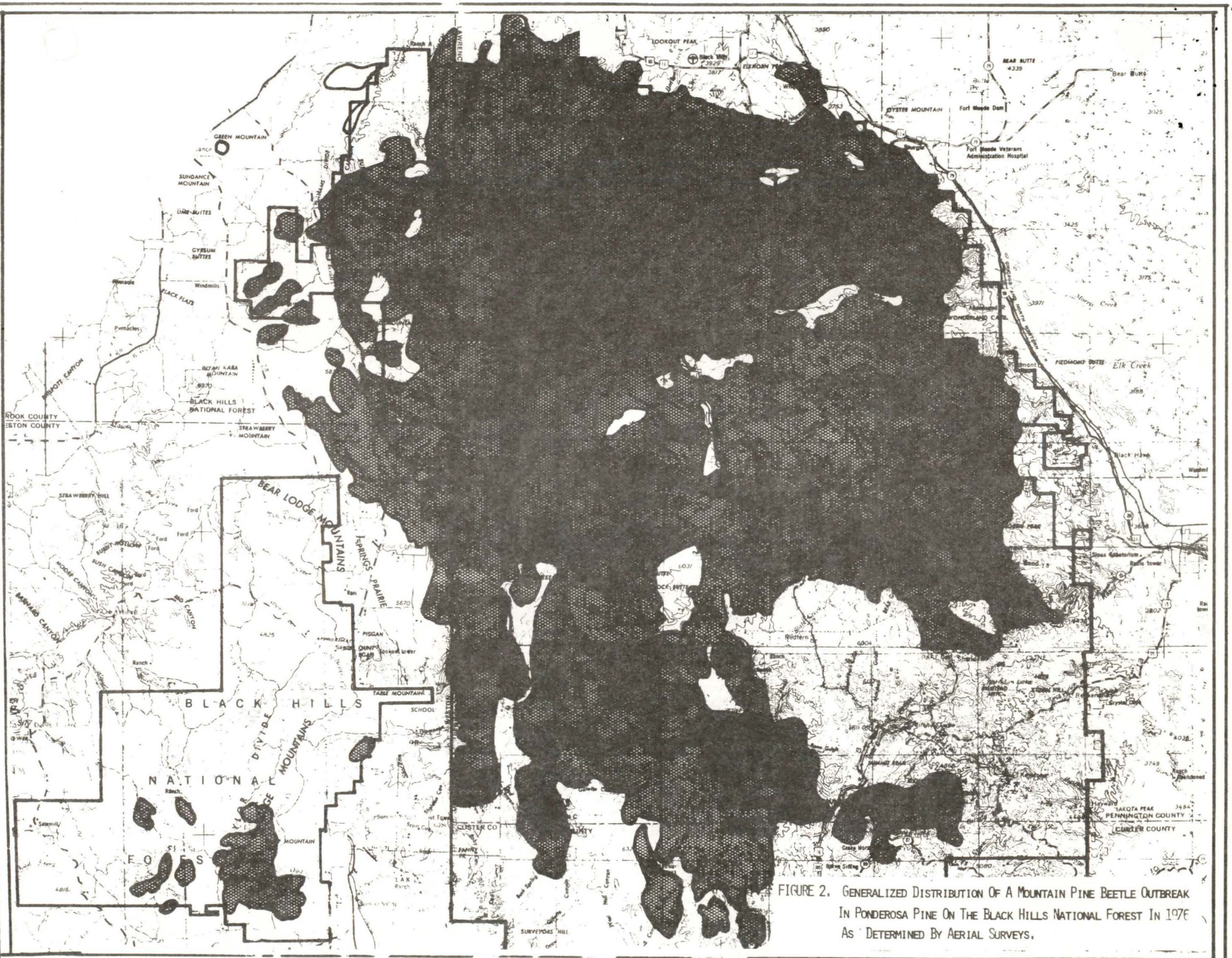

FIGURE 2. GENERALIZED DISTRIBUTION OF A MOUNTAIN PINE BEETLE OUTBREAK IN PONDEROSA PINE ON THE BLACK HILLS NATIONAL FOREST IN 1976 AS DETERMINED BY AERIAL SURVEYS.

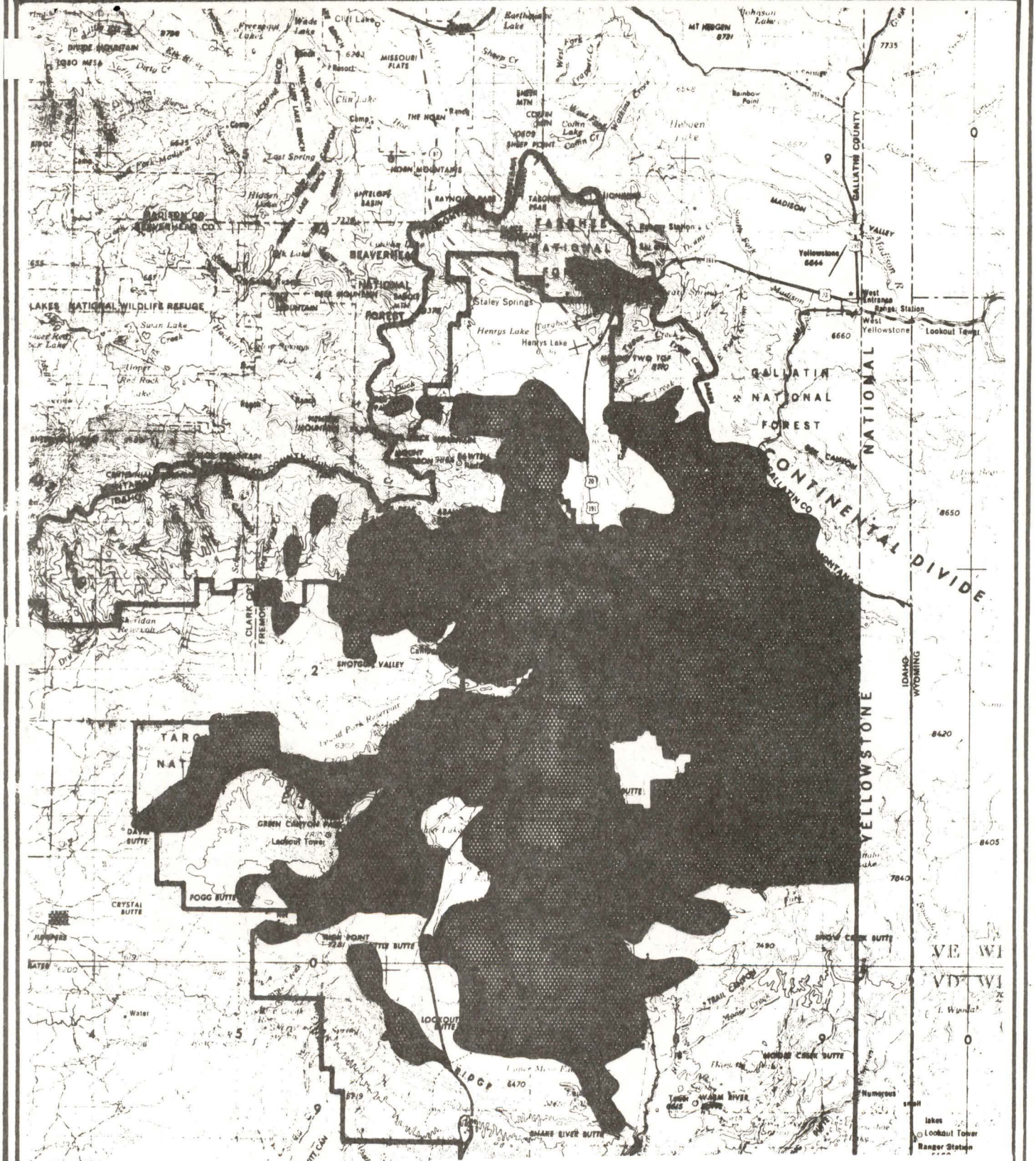

FIGURE 1. GENERALIZED DISTRIBUTION OF A MOUNTAIN PINE BEETLE OUTBREAK IN LODGEPOLE PINE ON THE TARGHEE NATIONAL FOREST IN 1976 AS DETERMINED BY AERIAL SURVEYS.

FINANCIAL ESTIMATE FOR 1977 MOUNTAIN PINE BEETLE DAMAGE SURVEY

- Targhee National Forest -

ACTIVITY	FISCAL YEAR 1977 R-4	1977 MAG	1977 Sub Total	1978 R-4	1978 MAG	1978 Sub Total	Total
A. Sketchmapping							
Computation - 10 days per diem @ $30/day	300						300
Aircraft ferry - 2 hrs @ $110/hour	220						220
			520				
B. Aerial Photography							
Flying - 15 hours @ $100/hour	1500						1500
Ferry - 5 hours @ $100/hour	500						500
Film - 4 rolls @ $250/roll		1000					1000
handling (mailing)	200						200
processing 800 ft @ $1.00/ft	800						800
testing - 4 rolls @ $10/roll	40						40
			4040				
C. Photo Interpretation							
Salaries - 2 GS-5's (2 PP) @ $358/PP	1432						1432
Travel (common carrier) 2 persons @ $170	340						340
Per Diem 40 days @ $30/day	1200						1200
			2972				
D. Ground Surveys (3 - 2 person crews)							
Salaries - 3 GS-5's (2 PP) @ $358/PP	1498			650			2148
3 GS-4's (2 PP) @ $320/PP	1350			570			1920
Per Diem (WAE) 120 days @ $30/day	2520			1080			3600
(PFT) 40 days @ $30/day	840			360			1200
Travel (WAE) 3 veh. @ $.12/mi for 1800 mi	458			190			648
(PFT) 1 veh. @ $.12/mi for 3000 mi	260			100			360
			6926			2950	
E. Technical Assistance (MAG)							
Per Diem 30 days @ $30/day	600			300			900
Travel (common carrier)	350			150			500
			950			450	
F. Computation and Analysis							
Computer time-sketchmapping		200					200
analysis					600		600
			200			600	
G. Miscellaneous							
Building Rental - 30 days @ $12.00/day	360						360
Telephone (computer link)	150						150
Equipment and Supplies	850						850
			1360				
Totals	15768	1200	16968	3400	600	4000	20968
Regional Overhead Assessment 6% of $20968							1258
						Total	$22226

FINANCIAL ESTIMATE FOR 1977 MOUNTAIN PINE BEETLE DAMAGE SURVEY

- BLACK HILLS NATIONAL FORESTS -

ACTIVITY	FISCAL YEAR 1977 R-2	1977 MAG	1977 Sub Total	1978 R-2	1978 MAG	1978 Sub Total	Total
A. Sketchmapping							
Computation - 10 days per diem @ $30/day	300						300
Aircraft ferry - 2 hrs @ $125/hour	250						250
			550				
B. Aerial Photography							
Flying - 25 hours @ $100/hour	2500						2500
Ferry - 10 hours @ $100/hour	1000						1000
Film - 6 rolls @ $250/roll		1500					1500
handling (mailing)	200						200
processing 1200 ft @ $1.00/ft	1200						1200
testing - 6 rolls @ $10/roll	60						60
			6460				
C. Photo Interpretation							
Salaries - 2 GS-5's (2 PP) @ $358/PP	1432						1432
Travel (common carrier) 2 persons @ $250	500						500
Per Diem 40 days @ $30/day	1200						1200
			3132				
D. Ground Surveys (3 - 2 person crews)							
Salaries - 4 GS-5's (2½ PP) @ $358/P	3222				358		3580
Per Diem (WAE) 80 days @ $30/day	2100				300		2400
(PET) 40 days @ $30/day	1000				200		1200
Travel (WAE) 2 veh. @ $.12/mi for 2500 mi	500				100		600
(PET) 2 veh. @ $.12/mi for 3500 mi	720				120		840
			7542			1078	
E. Technical Assistance (MAG)							
Per Diem 40 days @ $30/day	700			500			1200
Travel (common carrier)	450			450			900
			1150			950	
F. Computation and Analysis							
Computer time-sketchmapping		300					300
analysis					1000		1000
			300			1000	
G. Miscellaneous							
Building Rental - 30 days @ $12.00/day	360						360
Telephone (computer link)	150						150
Equipment and Supplies	850						850
			1360				
H. Reporting							
Publication processing					500		500
						500	
Totals	15462	1800	20494	5260	1500	3528	24022
Regional Overhead Assessment 6% of $24022							1441
						Total	$25463